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The Neuroscience and Art in Drawing

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Some art educators see neuroscience as a potentially significant and compelling support for art instruction (Jeffers, 2009; Schiferl, 2008; and, earlier, Edwards, 1979/1989/1999). At the same time, many art teachers are unprepared to make specific valid connections between their own teaching practices and related neuroscience studies. Claims of "brain-based" art instruction lack credibility because proponents do not establish specific connections to scientific research. This review narrows the search for connections between art teaching and neuroscience research to the teaching of observational drawing, a long-standing practice in many elementary and secondary art programs. Given that many practicing art teachers may be unfamiliar with the principles and theories of neuroscience, a review of all the studies related to teaching observational drawing is more than can be attempted here. The analysis identifies scholarly literature on drawing instruction and neuroscience studies carried out with human participants that can be seen as explaining or justifying observational drawing instruction. Cited references offer art teachers starting points they can pursue to support claims they might wish to make regarding the neurological benefits of teaching observational drawing.

Just as the brain searches for constancies and essentials, so does art.... The function of art is thus an extension of the function of the brain—the seeking of knowledge in an ever changing world
(Zeki, 1999, p. 11, 12).

Art education as a field might ask: What does neurobiology illuminate about learning to draw? Observational drawing provides an excellent example of a common ground for art and science fields, given the mutual interest in cognitive functioning and pictorial development. In neurobiology and cognitive neuroscience, researchers study the brain to understand how humans represent the world. Art education has set high expectations to help students represent the world, and agreed upon standards combine knowledge and skills with individual and societal aims. Humans "learn" to draw using the examples of others and benefiting from their own practice and experimentation with forms, media, and techniques. Art and science have a lot to share. Drawing provides one practice upon which to focus.

University professor Brian Curtis (2009) defines drawing from observation as "perceptual drawing," and this review follows the same idea. Early cognitive scientists adapted drawing and visual discrimination tasks to studies of the brain. After the mid 1980s, following imaging studies of damaged brains and as technology became less physically invasive, cognitive scientists continued using drawing and visual discrimination tasks to study normal visual systems (for overview, see Gazzaniga, Ivry and Mangun, 2002; Pylyshyn, 2003; Solso, 2003; Bear, Connors, & Paradiso, 2007).

From the task level, science and art begin to seek similar insights. *Inner Vision*, by Semir Zeki (1999) looks closely at artistic experiences using imaging technology to study the responses of individual cells in the visual system and how cells transmit visual information in the brain. Zeki's work involves elements of art (line, shape, color, motion) and how these work as compositional arrays. In his most recent book, *Splendors and Mysteries of the Brain*, Zeki (2009) explores the relationship between higher, abstract concepts of the brain

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(art, love, and beauty) and artistic creation. Zeki's premise deepens with his exploration of meaning as conveyed in the arts—unity being the defining relationship. Zeki (1999 & 2009) and Solso (2003) employ art and literary exemplars to offer explanations for why brains generalize knowledge gained from experiences to concepts, then to conscious perception. Evidence from the arts, highlighted by Zeki in 2009, suggests that human minds are organized along a common plan though with considerable individual variability. Personality, memory, and experience impact variability. Responses to images and drawings from memory tasks in neurobiological studies of the brain illuminate the act of drawing. If art teachers use scientific theories and findings to understand what happens neurologically when students draw the physical world, that knowledge may infer essential ways to teach the arts in a changing social world. Further, neurobiologists' and art teachers' mutual interests can impact how those outside of both fields recognize cognitive gains from an education in the arts.

> *As a teacher of art, I have come to understand the parallel importance of discipline, visual sensitivity, patience, eye/hand coordination, a rigorous work ethic, and a solid conceptual base as the essential tools needed to take full advantage of one's freedom (Curtis, 2009, p. ix).*

The freedom to draw imaginatively, to delve interpretively into the future, and to express creative intent, benefits from a foundation in observational drawing. As does Curtis, I find students vary tremendously in their ability to resolve observational drawing problems, and this conundrum between what they want to depict and what they can successfully depict constrains some students' ability to express that which cannot be viewed directly. Students say they find it difficult to generate drawings that match their mental concept, or they may be highly critical of their pictorial solutions to what they see before them. In either case, students' freedom to represent the "world" can be limited by inexperience in drawing. As I began studying neurobiology and cognitive neuroscience to inform my own teaching practice, I also started taking detailed notes in classes that stressed observational drawing to determine when and how students experienced problems. The techniques explored in this review can help students to improve their skills in drawing. Pylyshyn (2003) explains that how people see images as depictive can cause tension. He asks whether people [including art teachers and their students] can live with the fact that subjective experience may differ from "scientific" evidence about the nature of processing visual images. This tension between subjective experience and "scientific" evidence speaks to the very foundations of studio programs in drawing. Perhaps working through this tension is the "critical convergence" Donovan Walling (2002) describes when he proposes that as art education's definitions, neurobiological understandings, and cognitive processing perspectives expand and reconfigure in the minds of art teachers, then teaching can also change.

Among many studio areas, drawing predominates as a fundamental form of cognition. Neuroscience provides evidence of substantial links between normal vision and drawing from observation (Schiferl, 2008). In drawing from observation, complex perception includes acquiring information from the source, interpreting primary attributes with the media, finding emphases that convey the subject, and organizing forms as a composition. The unity or "finished" state of a concept, Zeki (2009) says, resides within the brain rather than with the drawing or the object. Interest, persistence, opportunity, instruction, and visual memory seem to be critical variables in drawing and cognition in general.

Art instructors traditionally use exercises or projects to focus the attention of beginning drawing students on specific features of inanimate and life models. In observational drawing students attempt to capture contours, implied or actual movement/gestures, shading, and illusionistic space. Exercises are generally quick and energetic, while art projects involve lengthy study; taken together these practices constitute a problem-based approach to drawing. In studio settings where "visual neutrality" is the desired outcome, teachers talk with their students about the mental and physical skills required to draw class projects from direct observation. The two-dimensional curves that drawing students think they are following on models change imperceptibly with shifts of heads, shoulders, arms, and hands as they draw. Their eyes record changing viewpoints. While the experience of vision seems to be "seamless" (see Schiferl, 2008), considering three-dimensional models usually causes students' eyes and hands to become confused. Instability becomes apparent in the overlay of sketchy and reworked lines, which are in fact multiple concepts of the model. However, those same imprecise lines and overlays in drawings can be interpreted by viewers as energetic (Zeki, 2009). Curtis (2009) explains that marks "mirror the fluctuating energy and irregular patterns found in biological life…[and] line quality can incorporate much of the same feeling of energy and vitality" (p. 3).

Drawing from life, as experienced in K-12 classrooms, typically means drawing one's self, fellow students in the class, or a costumed model. Working from live models requires different movements of the shoulder, arm, hand, and fingers to depict line, shading, and mass. Clothing the figure makes it difficult for beginners to see spatially the body's articulation; thus, Mendelwitz, Wakeham, and Faber (2003) discuss in their drawing text the importance of merging artistic, scientific, and mathematical conventions in students' minds. For example, shading emphasizes parts of the body away from the light; open contours suggest light falling directly on subjects. Composing the figure on the paper plane, deciding scale, proportion and placement, and alluding to spatial orientation presuppose mathematical understanding. Medelwitz et al. include scientific study of anatomical structure and the body's proportions as part of preparing to draw from life.

Simple, neurologically sound procedures can help students to interpret what they see—

for example, closing the less dominant eye, thus relying solely on monocular vision, reduces dimensionality (I learned this as a child). A student can use a pencil or ruler to establish orientation of line for an object, which s/he can then replicate on the paper. As Zeki (2009) notes, cells abstract "the property of verticality" and selectively respond to directionality. It is likely that good art practices such as standing up to draw, facing directly toward a setup, sighting angles with a pencil, and using a view finder held some inches from the eye work because these have a biological basis. The body's orientation vertically in space, both eyes fully engaged, with the pencil as a reference, or narrowing the field of vision assists the drawer by "promoting sensory alertness and physical responsiveness" (see informative discussion of "mechanics" by Curtis, 2009, p. 16).

A Brief History of Art Education's Interest in Problems of Perception

In 1954, Rudolf Arnheim (1954) queried what was then "recent progress" in the psychology of perception. In *Visual Thinking* (1954), Arnheim discussed the drawings of children as early indicators of visual expression. Children's pictorial ideas, Arnheim (1954) surmised, sprang from direct observation of the sensory world; but success for children meant finding shapes that evoked their general experience of the world. In drawing, children determine linear approximations of the visual world and depict those perceptions on a flat surface. Children move from simple constructions to somewhat conventional presentations of objects. In Arnheim's words, "To perceive an object means to find sufficiently simple, graspable form in it" (Eisner & Ecker, 1954/1966, p. 257), or a pictorial equivalence guided by some graphic logic in the child.

Gallo, Golomb, and Barroso (2002) designed a cognitive study comparing Arnheim's theory with Piegetian and neo-Piagetian assumptions about conceptual-spatial tasks and working memory constraints. The researchers noted that the neo-Piagetians added detailed analyses of tasks and examined cultural and educational factors influencing drawing of students ages five to nine. After talking with their young subjects, the authors concluded that children who defined success and solution as photographic realism had more understanding of spatial relations than did the subjects who appropriated graphic logic and solutions secondhand from peers and adults. More successful students could make two dimensional equivalents of spatial relationships (in front of/or behind, closer = larger, far away = less distinct. Contrastingly, Arnheim (1969) reminded teachers of the need to recognize as intelligent other graphic solutions to pictorial problems that reveal the variety of graphic logics (including, but not limited to, non-Western ideas of space, i.e. stacked space).

Arnheim extended the range of scholarship on spatial understandings to university populations. He (1969) reported that an "intelligent and sensitive" college student in the drawing class failed initially to understand graphically the oblique shape of a box lying on a table. The college student recognized the oblique orientation after Arnheim demonstrated the concept with a drawing. June King McFee also considered visual perception among young adults. McFee (1962/1966) said individuals develop a "screen" through which to view the world; and, that screen is heavily influenced by personality, instruction, and culture.

Brent Wilson and Marjorie Wilson (1977) queried high school and college students about the process of learning to draw. Their tasks required drawing certain objects from memory. They asked where students learned to draw and recorded information about who taught them. Students reported learning from adults, siblings, and peers. The Wilsons found that only a few students remembered learning representations they picked up from art classrooms. They picked up most drawing ideas in the home, from contemporary cartoons, or from how to books. Wilson and Wilson questioned the assumptions of their day that all students develop drawing expertise on their own with practices that only emphasized direct observation and learning to concentrate. Wilson and Wilson suggested that actively exploring drawing solutions gives art students increased choices to work from in making drawings.

The tension between what students "know" about an object, and what they record directly from observation becomes visible when students combine the two approaches in drawings, though "combination" drawings often have a certain naïve charm (Curtis, 2009). Donovan Walling (2000), who began his career as an art teacher, thinks that the Information Age has "diminished …the viability of traditional, often culture-bound, canons of knowledge…. [Thus], the traditional canon…must be abandoned, or, at least, adapted and opened" (p. 39). Walling (2000) proposes that teachers ought not "dictate where students should go; [rather] …give them mental equipment and practical tools and encourage them to begin the journey" (p. 48). Pedagogical logics associated with perception can be experiential, constructivist, schema driven, Socratic, process specific, disciplined, production focused, and standards based (see Walling, 2000); each logic experienced increases choices for students. As Curtis suggests (2009) the biology of the body and its visual system can be the basis for a model for teaching drawing. A biologically informed model admits various logics (both pictorial and pedagogical), and has transformative possibilities.

Discussion of Pedagogical Models with Drawing

Walter Smith (1875/1966) advocated that teachers should introduce freehand drawing after pupils master outline representation copied from cards. He designed exercises that emphasized proportion, plane geometry, and "beautiful" forms. Teachers employed freehand illustrations to teach children aspects of plane geometry, and were to be "forgiving" of little children's efforts in freehand or model drawing. Smith emphasized that the simplified shapes allowed "the eye to be educated" through exercises that considered one idea at a time. Smith also advocated dictation exercises where students produce the called for figure from its verbal equivalent; and, he had

students reproduce forms from memory. Smith required that students place the drawing paper in front of them with edges parallel to the edge of the desk or table. However, they could make curves with the paper in any orientation, allowing the natural movement of the hand as a compass point. If art educators look beyond the limitations of Smith's model and adapt the simplified ideas to initial drawing instruction, they can, for example, emphasize the role of center mass and teach about line orientation and angles—known today by neuroscientists as primary, cellular level, activation sites in the visual system (Zeki, 1999; Solso, 2003; Pylyshyn, 2003) and by art teachers as spatial aspects representing primary visual features in compositions.

Nicolaides (1941) explored "natural" ways to draw. The basic idea behind Nicolaides' instructional plan was the "necessary relationship" between intent and action. His exercises emphasized ways of looking at models and objects and specified the coordinating physical motions; he intended these exercises to help drawing students glean knowledge from their efforts. As did Smith, Nicolaides isolated attributes of drawing so that students could concentrate on simple visual ideas. Over time he expected these exercises to become habitual when working from three-dimensional subjects. Nicolaides used contour, gesture, and cross-contour exercises to coordinate the hand with eye movement. Drawing students could only look at the paper to locate new starting points. Students could give drawing projects a three-dimensional quality by following the volumetric attributes as well as the length and width of forms. Nicolaides' approaches have strong biological associations. Gesture drawing, for example, seeks the defining line as a visual starting place and relies on physical analogs recorded as marks. Cross-contour continues the analogue of touch, allowing for informative orientation and consideration of mass while eyes explore the form visually.

An academic pedagogical model emphasizes blocking in basic forms by establishing angles and sight lines. Exercises and projects evolved from Renaissance sources, through the 19th-century academies, and to Russian artists in the early 20th century (as an example, see Curtis, 2009). Academic drawing emphasizes "accuracy" in representations of three-dimensional forms in space, on two dimensional surfaces. Students work from simple still life forms to more complex compositions. Academic drawing pedagogy has evolved in our century, going beyond exercises to the project level (see, Chaet, 1970/1983; Wakeham, 1976; Betti & Sale, 1986). Deeply seated in Western culture, academic drawing coordinates eye movements to drawing from observation and prioritizes the relationships of forms in pictorial space.

Using Neurobiology to Guide Teaching

Pylyshyn (2003) has explored the belief that people's beliefs and expectations condition what they "see." Art education can already substantiate neurologically some of our field's best drawing practices, especially those depending upon coordination of reference points. Pylyshyn proposed that educators look at "early vision" as a starting point. In early vision, sensation and response depend upon biological and chemical action, and follow physical principles in the visual brain (see Zeki, 2009). Students of drawing then could progress through the more intuitive ways of drawing that depend upon approximating vision—recording the directionality of contours from three dimensional forms (Nicoliades, 1941; Curtis, 2009). With the greater deliberation involved, "seeing" broaches into interpretation and emphasizes technique, thus engaging higher functions of the brain and different types of explanatory principles (see Pylyshyn, 2003). Subtlety enters into drawings and expression with students' greater deliberation (see Zeki, 2009). Academic drawing projects represent the highest "task demand" because the eyes are scanning a larger area to accomplish the project. Pylyshyn (2003) explains the phenomena: "…the 'scanning effect' is cognitively penetrable by noting that the observed behavior depends both on the form of the image and on the particular processes that use it, so that the differences in the process…might account for the different results one gets in different contexts" (p. 307-308).

Academic drawing leaves a visible record of what brain and hand are accomplishing together. Understanding what happens in the brain with observational drawing helps art teachers to guide students in mapping knowledge of an ever changing physical world. An art education pedagogy sensitive to neurobiological development rather than age enhances students' ability to record what they come to know.

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TRANSLATIONS

Highlights

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1. Art and science use similar tasks when seeking "essentials" in a visible world, thus it is possible to work across fields.

2. Human minds are organized along a common plan with considerable individual variability.

3. Simple, neurologically sound procedures help students interpret what they "see."

4. Art education has been interested in perception from its early beginnings as a field of study.

5. The biology the body and understanding of its visual system can be the basis for a model of teaching drawing with transformative possibilities.

6. Exercises that look at object features, exercises in drawing naturally, and academic approaches to drawing projects share a common concern with knowing the visible world.

7. Understanding what happens in the brain with observational drawing helps teachers guide students in their search for knowledge of an ever changing physical world.

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